Four West Slope Basin Roundtables

Joint Meeting Agenda

Thursday, June 20, 2019; 10 a.m. to 3 p.m.

Ute Water Building, 2190 H 1/4 Road, Grand Junction, CO 81505

- Colorado Basin Roundtable
- Gunnison Basin Roundtable
- Southwest Basin Roundtable
- Yampa-White-Green Rivers Basin Roundtable

4WSBRT Zoom Access to the meeting

Topic: Western Slope Roundtables
Time: Jun 20, 2019 10:00 AM
Mountain Time (US and Canada)

Join Zoom Meeting
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Meeting ID: 226 423 206
Find your local number:
https://zoom.us/u/abFT3yf6Yf

10:00 Welcome and Purpose of the Meeting
Chairs: Jackie Brown, YWG; Kathleen Curry, Gunnison; Jim Pokrandt, Colorado; Mike Preston, Southwest

10:15 Drought Contingency Plan Overview
Karen Kwon or Amy Ostdiek – Colorado Attorney General's Office

10:30 Phase III Risk Study Update
John Carron, Hydros Consulting; John Currier, Chief Engineer, Colorado River District

11:30 Phase III Risk Study Q&A: Panel with John and John

12:00 Box Lunches

12:30 CWCB Update on its Demand Management Workgroups
Brent Newman

12:45 Roundtables-Level Demand Management Workgroup Updates
Representatives from the 4WSBRTs

1:15 IBCC Demand Management Initiative
Russ George, IBCC Director

1:35 Colorado Water Bank Workgroup Update/Secondary Impacts Study
Chris Treese, Colorado River District

1:50 Colorado Water Plan Funding
Tim Wohlgenant

2:10 Facilitated Discussion of What's Next

3:00 End of Meeting

Joint Four West Slope Roundtable
Colorado River Risk Study Discussion Guide

6/20/19 - Ute Water Building - Grand Junction, Colo.

At the December 14, 2014 joint meeting of the four West Slope Roundtables, participants requested information to facilitate intra-basin discussion of demand management, should low levels at Lake Powell require that tool, as well as discussion of potential future development of West Slope Colorado River system supplies. In response, the Colorado River District and Southwestern Water Conservation District proposed Phase I of the Colorado River Risk Study. Each district and each Roundtable shared in the costs. This continued into a Phase II. Today we will learn about the work of Phase III. Keep in mind that the work resulting from the Risk Study is for discussion purposes only, that it does not represent the official position of any entity with respect to factual or legal matters concerning the Colorado River.

Major aspects of Phase I

1. To maintain the storage levels at Lake Powell above elevation 3,525 feet (above sea level), **demand management would be occasionally needed under all different hydrology and demand scenarios.** Without corrective action (implementing Drought Contingency Plans), **the risk that Lake Powell would be drained below critical levels is real (10-20%).**
2. **Demands and hydrology matter, the drier the hydrology, the more often demand management is needed and the larger the shortages that must be covered. Demands also matter**. For the same hydrology, the higher the level of consumptive uses, the more often demand management is needed**. A 10% increase in Upper Basin depletions roughly doubles the frequency that demand management is needed and doubles the amount of the large shortages** that will have to be covered by demand management.
3. During the rare severe droughts such as 2000-2004 or the 1950s, the amount of water needed by demand management can exceed 1 million acre-feet -- far more than the amount of water that could be obtained by demand management in a single year**. This means that, as a practical matter, demand management will have to be designed as a water bank or reserve account,** where smaller annual contributions are made annually into a “bank” then released to Lake Powell when needed.

During the presentations to the Roundtables, there were many questions about how the implementation of demand management would impact projects and water use within the individual basins. The Phase I study used the Bureau of Reclamation’s CRSS (model) which is a

good model for operating the Colorado River system (the big reservoirs like Powell and Mead) but can't be used to look at the details of what happens within the West Slope sub-basins. To address these more specific questions and to consider further system questions, we moved forward with phases II and III.

Major aspects from Phase II

Phase II had two basic technical tasks. The first task was to again use the Bureau of Reclamation's Colorado River Simulation System (CRSS) computer model to look a paleo-hydrology scenario and to consider in more detail a demand-management approach utilizing a demand-management concept of putting a smaller amount (for example 100,000 acre-feet per year) into a dedicated water bank, then using the banked water for demand management. The results of this task were consistent with the Phase I results. **The concept of water bank works provided dedicated reservoir space is available and there is water in the bank when the drought begins.**

The second task was to look at how to use CRSS in conjunction with Colorado's State-Mod computer model to look at the basin-specific impacts of demand management. State-Mod is water-rights based and models the operation of diversions and projects within Colorado (but ends at the state line). **The task results were successful and we now have the ability look at the basin-specific questions related to demand management options.**

Major aspects from Phase III

(See the full slide deck appended to this packet)

GENERAL OBSERVATIONS

1. Of Colorado's approximate 2.5 million acre-feet (maf) of average annual consumptive use, approximately 1.6 maf is attributable to Pre-Compact rights, and approximately 900,000 acre-feet is Post-Compact

2. Transmountain diversions (TMDs) constitute over half of the Post-Compact depletions (~56%)

3. Because of #2, the Colorado Mainstem users comprise 2/3 of all Post-Compact uses

4. The large TMDs often end up being the swing call, even across different volumetric reductions

5. Allocating deficit volumes pro-rata by sub-basin depletions results in substantially different administration dates for certain sub-basins when compared to a state-wide curtailment of all Colorado River water users.

What does modeling tell us about risk?

Model analysis from Phase III of the Risk Study using the 1988-2015 Stress Test Hydrology indicates:

1. The likelihood of Lake Powell Dropping below 3525 feet in elevation at some point in the next 25 years is about 39% (11 of 28 traces).

2. The likelihood of the 10-year running average Lee Ferry volume dropping below 82.5 maf is about 46% (13 of 28 traces)

3. The likelihood of the 10-year running average Lee Ferry volume dropping below 75 maf is about 0%* (0 of 28 traces)

An increase in annual Upper Basin Consumptive Use averaging 11.5% (approximately 500,000 acre-feet** roughly doubles the risk of #1 and #2.

*Note that previous Risk Study simulations and Reclamation runs have shown likelihoods greater than zero at the 75 maf threshold (Model assumptions matter!)

**The Upper Colorado River Commission Demand Schedule anticipates reaching that level of use by about 2037.

13

A Closer Look at Pre/Post Compact Depletions

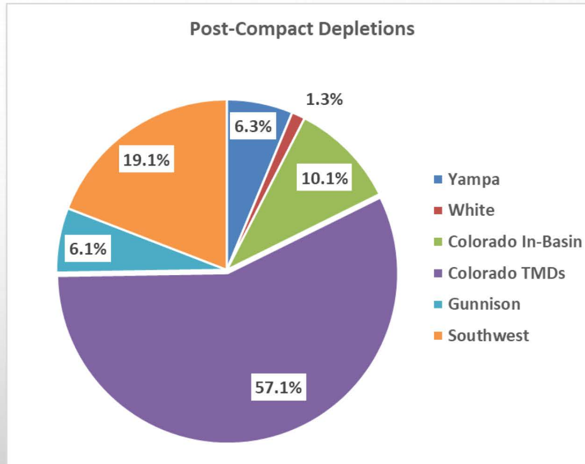
Basin	Average Annual Depletions (acre-feet)		
	All Users	Pre-Compact	%Pre-Compact
Yampa	196,982	138,544	70%
White	62,060	50,173	81%
Colorado	1,220,386	594,169	49%
In-Basin	*669,397*	*574,997*	*86%*
TMDs	*550,989*	*19,173*	*3%*
Gunnison	552,418	495,147	90%
Southwest	500,717	322,561	64%
Total	2,532,564	1,600,594	63%

All Results Presented herein are Preliminary and Subject to Change

14

Who is Impacted by Curtailment of all Post-Compact Rights?

Basin	Average Annual Depletions (af)	
	Post-Compact	% of Total
Yampa	58,438	6.3%
White	11,887	1.3%
Colorado	626,216	67.2%
In-Basin	*94,400*	*10.1%*
TMDs	*531,816*	*57.1%*
Gunnison	57,271	6.1%
Southwest	178,157	19.1%
Total	931,969	100.0%



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Big River Challenges: Background Conditions, Actions and Planning

1. Since 2000 to now, the Colorado River system has experienced an extended dry period. **<u>During this 19-year period, the average natural flow at Lee Ferry has averaged about 12.4 million acre-feet per year through 2017.</u>** This is about 20% below the long term (1906-2015) average of 14.8 million acre-feet per year.
2. Science suggests that **<u>as regional temperatures increase, this drying trend will continue.</u>**
3. At the beginning of 2000, system-wide reservoir storage (Mead, Powell and the other CRSP reservoirs) was nearly full. **<u>Today system storage is less than 50% full.</u>**
4. **<u>Annual releases from Glen Canyon Dam (Lake Powell) are controlled by the 2007 Interim Guidelines.</u>** The guidelines were negotiated by the basin states (and the federal agencies) and approved by the U.S. Secretary of the Interior. Under the guidelines, the operations of the Lakes Mead and Powell are integrated. The guidelines will expire after water year 2026 and will have to be renegotiated. The negotiations are scheduled to commence in 2020.

5. **In 2013, to address continuing drought, the basin states began preparing Drought Contingency Plans (DCPs).** There are now two integrated plans, one for the Upper Basin and one for the Lower Basin.
6. **Colorado's Water Plan** was finalized in November 2015. The plan includes what is referred to as the "conceptual framework." The framework was negotiated and approved by the Interbasin Compact Committee (IBCC). **The principles are intended to guide the development of new supplies and the protection of existing uses** within Colorado. **Principle #4 provides that Colorado will take a proactive approach to avoiding a future compact deficit. The program will cover existing uses plus a reasonable** growth within the Colorado River Basin, but not new transmountain diversions.

Drought Contingency Plans (DCPs)

1. The **Upper Basin DCP** includes three basic elements:
   a. **Drought operations of the Colorado River Storage Project (CRSP) storage reservoirs upstream of Lake Powell – Blue Mesa, Navajo and Flaming Gorge Reservoirs.** These three reservoirs were authorized under the same federal law as Lake Powell, the 1956 Colorado River Storage and Participating Projects Act. Although smaller, they have the same basic purpose as Lake Powell – re-regulation of the Colorado River so that the Upper Basin can develop its water resources while meeting its compact obligations at Lee Ferry. Under Drought Operations, additional releases will be made from these reservoirs to help maintain Lake Powell above critical levels.
   b. System augmentation: this consists of **cloud seeding and non-native vegetation control of phreatophytes.** This element of the DCP is already underway.
   c. **Demand Management: Under the DCP, the Upper Division states agree to investigate programs to reduce consumptive uses** (referred to as demand management) as needed to avoid Lake Powell storage dropping below critical levels. None of the states, including Colorado, has made a formal decision to implement demand management. The commitment is only to study the feasibility of demand management.

What are the critical storage levels in Lake Powell?

The goal of the Upper Basin DCP is to take proactive measures to always have a storage cushion in Lake Powell. The theory is that as long as the Upper Basin has some storage available, it will have the water on hand to meet its downstream commitments**.** **The current target (which is subject to change) is elevation 3,525 feet above sea level. At this this elevation, there is only 2 million acre-feet of storage available until minimum power.** There is another 4 million acre-feet of storage below minimum power, but above the low-level outlet works (this is referred to as inactive storage).

While the primary purpose of the DCP is to pro-actively meet downstream commitments, maintaining minimum power has major side benefits. Power revenues, pay for the operation of the CRSP reservoirs, repay the federal government for the costs of the projects and fund critical environmental programs. Further, because the capacity of the dam's outlet works drops with the elevation of the reservoir, dropping below minimum power may prevent the Upper Basin from actually meeting its downstream requirements. This is referred to as a compact hole.

2. **The Lower Basin DCP,** which covers mainstream uses in and below Lake Mead – not the Lower Basin tributaries – is designed to add to the shortages that are required by the 2007 Interim Guidelines. As Lake Mead drops toward critical storage levels, **defined as elevation 1,020 feet in Lake Mead**, the three Lower Division states ramp up their conservation measures to preserve storage in Lake Mead. **If Lake Mead was forecast to drop below 1,025 feet, then the combined effect of the Lower Basin DCP and the 2007 Interim Guidelines results in a reduction of about 1.4 million acre-feet per year.**
3. Minute 323 with Mexico: **Under Minute 323,** which is effective through the term of the 2007 Interim Guidelines, Mexico both shares shortages when the 2007 Interim Guidelines require a shortage and, similar to the DCP, they will implement additional conservation measures.

Total Contemplated Lower Basin Volumes (in KAF)
2007 Interim Guidelines, Minute 323, Lower Basin Drought Contingency Plan &
Binational Water Scarcity Contingency Plan

Lake Mead Elevation (ft msl)	2007 Interim Guidelines Shortages		Minute 323 Delivery Reductions	Total Combined Reductions	DCP Contributions			Binational Water Scarcity Contingency Plan Savings	Combined Volumes by Country US: *(2007 Interim Guidelines Shortages + DCP Contributions)* Mexico: *(Minute 323 Delivery Reductions + Binational Water Scarcity Contingency Plan Savings)*					Total Combined Volumes
	AZ	NV	Mexico	***Lower Basin States + Mexico***	AZ	NV	CA	Mexico	*AZ Total*	*NV Total*	*CA Total*	*Lower Basin States Total*	*Mexico Total*	***Lower Basin States + Mexico***
1,090 - >1,075	0	0	0	***0***	192	8	0	41	192	8	0	*200*	*41*	***241***
1,075 - >1050	320	13	50	***383***	192	8	0	30	512	21	0	*533*	*80*	***613***
1,050 - >1,045	400	17	70	***487***	192	8	0	34	592	25	0	*617*	*104*	***721***
1,045 - >1,040	400	17	70	***487***	240	10	200	76	640	27	200	*867*	*146*	***1,013***
1,040 - >1,035	400	17	70	***487***	240	10	250	84	640	27	250	*917*	*154*	***1,071***
1,035 - >1,030	400	17	70	***487***	240	10	300	92	640	27	300	*967*	*162*	***1,129***
1,030 – 1,025	400	17	70	***487***	240	10	350	101	640	27	350	*1,017*	*171*	***1,188***
<1,025	480	20	125	***625***	240	10	350	150	720	30	350	*1,100*	*275*	***1,375***

The US will work to create or conserve 100,000 af or more of Colorado River system water on an annual basis to contribute to conservation of water supplies in Lake Mead and other Colorado River reservoirs. All actions taken by the United States shall be subject to applicable federal law, including availability of appropriations.

Principle #4 of the Conceptual Framework in Colorado's Water Plan

[Chapt. 8, pp 14-17]

Principle #4 of the Framework is a critical policy statement and the primary reason the West Slope Roundtables asked for the risk study. This principle states that "a collaborative program that protects against involuntary curtailment is needed for existing uses and some reasonable increment of future development in the Colorado River system, but will not cover a new TMD." The supporting information notes that the collaborative program "should provide a programmatic approach to managing Upper Basin consumptive uses, thus avoiding a Compact deficit and insuring that system reservoir storage remains above critical levels such as minimum (power)." The similarities between the objectives of the Upper DCP and the collaborative program are obvious. During the IBCC discussion of the Framework, it was recognized that the collaborative program and the long term Upper Basin DCP would be the same. Drought operations of the CRSP reservoirs and demand management would be the primary components.

Colorado River Risk Study Phase III

An Update for the 4 West Slope Basin Round Table Meeting

Grand Junction, Colorado

June 20, 2019

Disclaimer: The findings presented herein are for discussion purposes only, and do not represent the official position of any entity with respect to factual or legal matters concerning the Colorado River.

All Results Presented herein are Preliminary and Subject to Change

Disclaimer Part 2:

1. All Models are Wrong, some are Useful – George Box

2. Any opinions expressed herein are my own

3. Don't shoot the messenger

Colorado River Risk Study

- Originated from joint West Slope BRT discussions and reflection on DCP process
- Funding via Colorado River District, Southwestern, West Slope BRTs (CWCB)
- Principle 4 of the IBCC Conceptual Framework from the Colorado Water Plan: *A collaborative program that protects against involuntary curtailment is needed for existing uses and some reasonable increment of future development in the Colorado River system, but it will not cover a new TMD*.
- Phase I completed Fall 2016; Phase II completed Fall 2018
- Takeaways thus far:
  1. Under current conditions and operating policies, the likelihood of reaching critical elevations or a compact deficit is low, but impacts could be significant
  2. Hydrology and amount of future growth in the Upper Basin are key drivers of risk
  3. It is not just a Lower Basin / Structural Deficit problem (hence the UB DCP plan)

Lake Powell and the Colorado River Compact

Upper Basin Objectives:

1. Avoid Compact Deficit which *might* lead to curtailment
2. Protect Lake Powell (Elevation 3525' is threshold for Lower Elevation Balancing Tier. 3490' is minimum power pool)

Risk Drivers:

- Hydrology
- Consumptive Use
- Low Reservoir Storage Conditions

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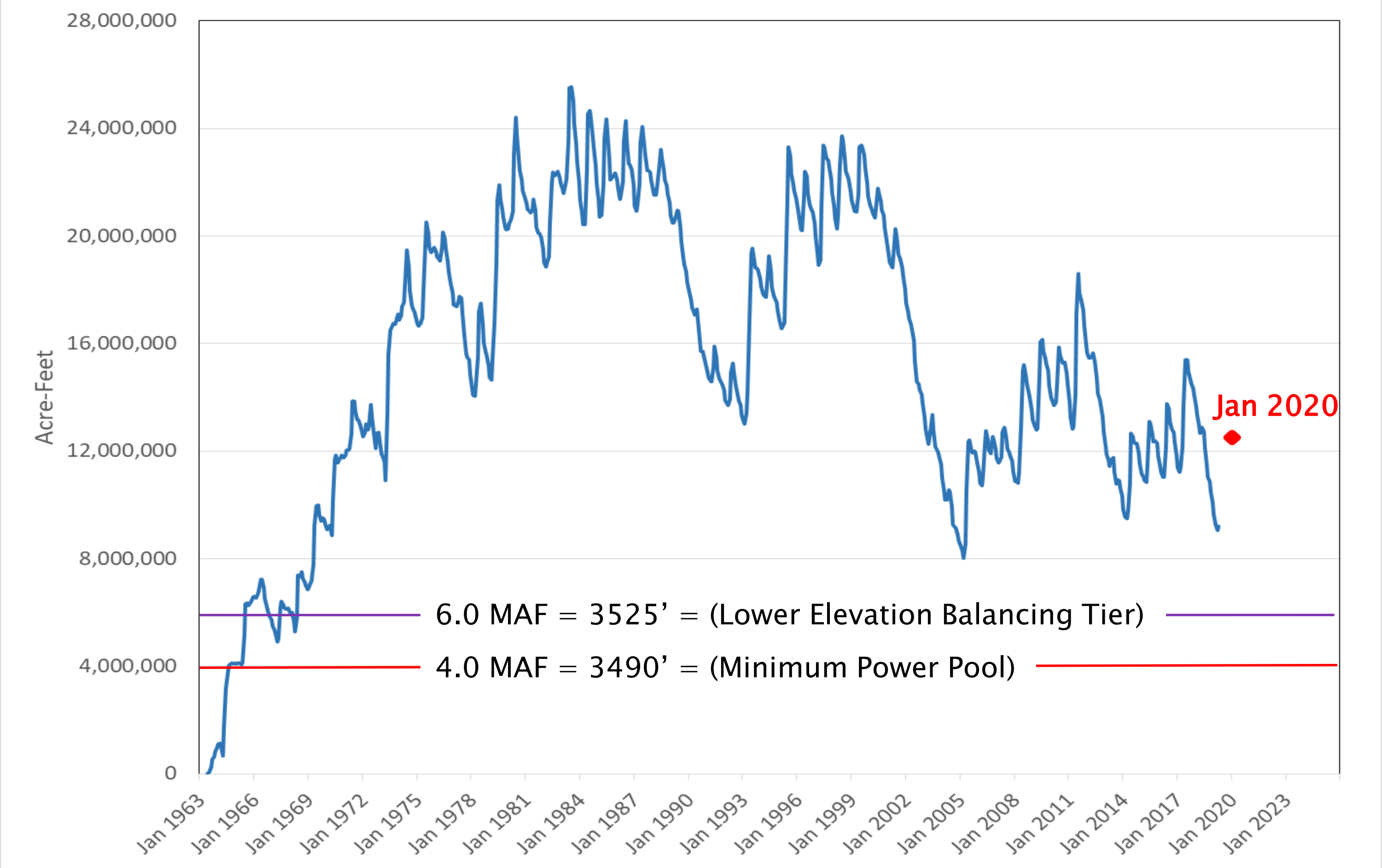
Lake Powell Storage



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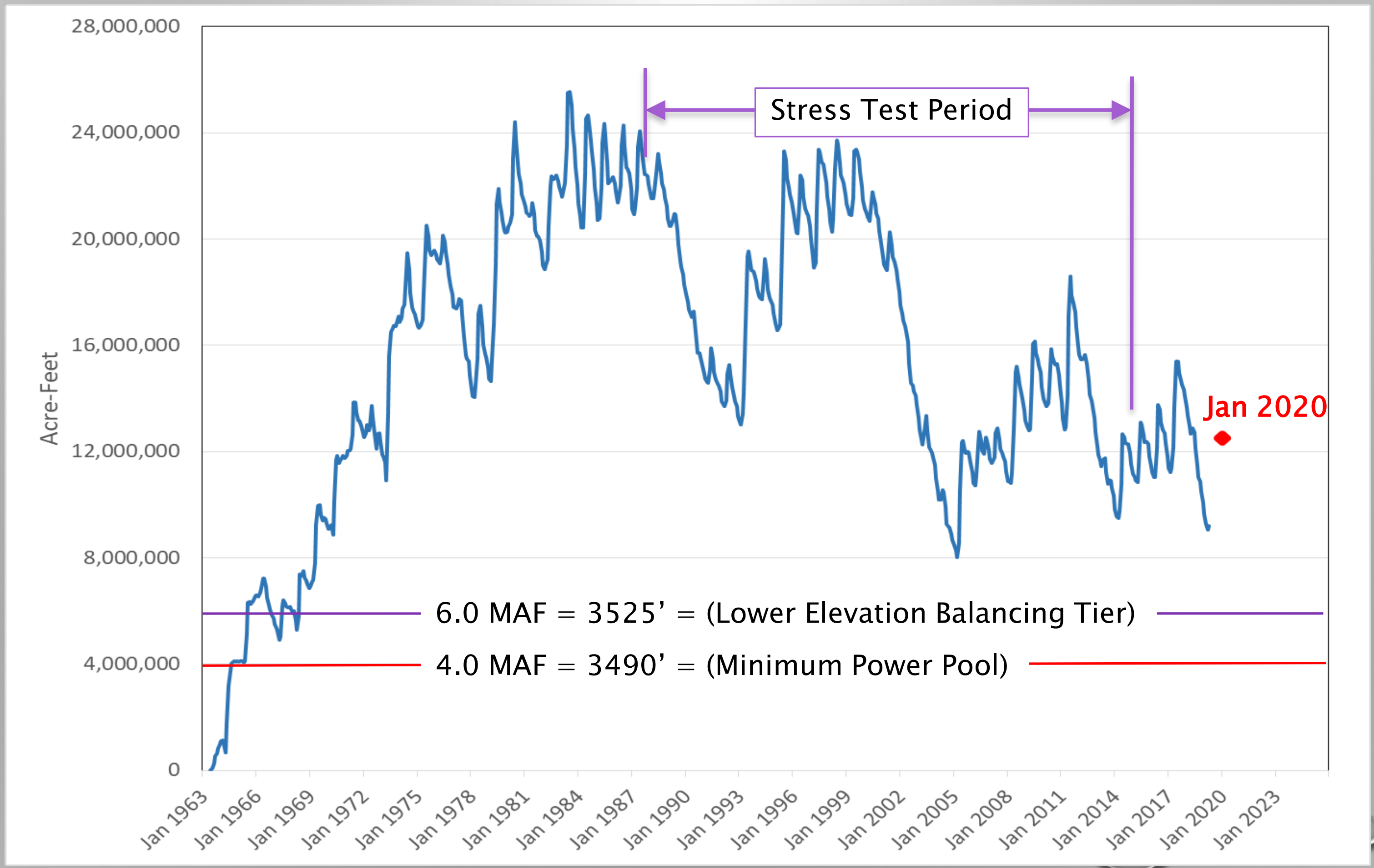

What does Modeling tell us about Risk?

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3. The likelihood of the 10-year running average Lee Ferry volume dropping below 75 Maf is ~ 0%* (0 of 28 traces)

An increase in annual Upper Basin Consumptive Use averaging 11.5% (approximately 500 Kaf)** roughly doubles the risk of #1 and #2.

*****Note*** *that previous Risk Study simulations and Reclamation runs have shown likelihoods greater than zero at the 75 Maf threshold (<u>Model assumptions matter</u>!)*

***The UCRC Demand Schedule anticipates reaching that level of use by ~2037.*

Pre-Emptive Water Management Options

The recently approved Drought Contingency Plans (DCPs) provide a mechanism for protecting critical elevations at both Lake Powell and Lake Mead.

The Upper Basin DCP has three components intended to reduce or eliminate the risk of reaching critically low Lake Powell levels:

1. Cloud Seeding and Phreatophyte Control (Ongoing)
2. Drought Operations of CRSP storage facilities (Subject to consultation between UB States and Reclamation)
3. Exploration of voluntary and compensated Demand Management program, including use of 500,000 af water bank in one or more CRSP facilities

If these (and possibly other) pre-emptive actions are insufficient to protect Lake Powell levels, and if as a result Lake Powell was unable to release sufficient water past Lee Ferry, a Compact Deficit could result.

A Compact Deficit could result in Involuntary Curtailment

Questions:

- How much Colorado River water does the State of Colorado use?
- How much of Colorado's depletions are pre-compact?
  - How is this volume split up across the west slope basins (including TMDs)?
  - How much post-compact use could be called out?
  - Where are those post-compact uses?
- What are potential approaches to "Sharing the Pain"?

Colorado's Consumptive Use of Colorado River Water

Basin	Annual Depletions (acre-feet)		
	Minimum	Average	Maximum
Yampa	173,547	196,982	215,193
White	48,550	62,060	70,397
Colorado	1,117,487	1,220,386	1,345,192
In-Basin	*650,887*	*669,397*	*692,333*
TMDs	*466,600*	*550,989*	*652,859*
Gunnison	481,626	552,418	601,030
Southwest	335,365	500,717	556,627
Total	2,156,575	2,532,564	2,788,439

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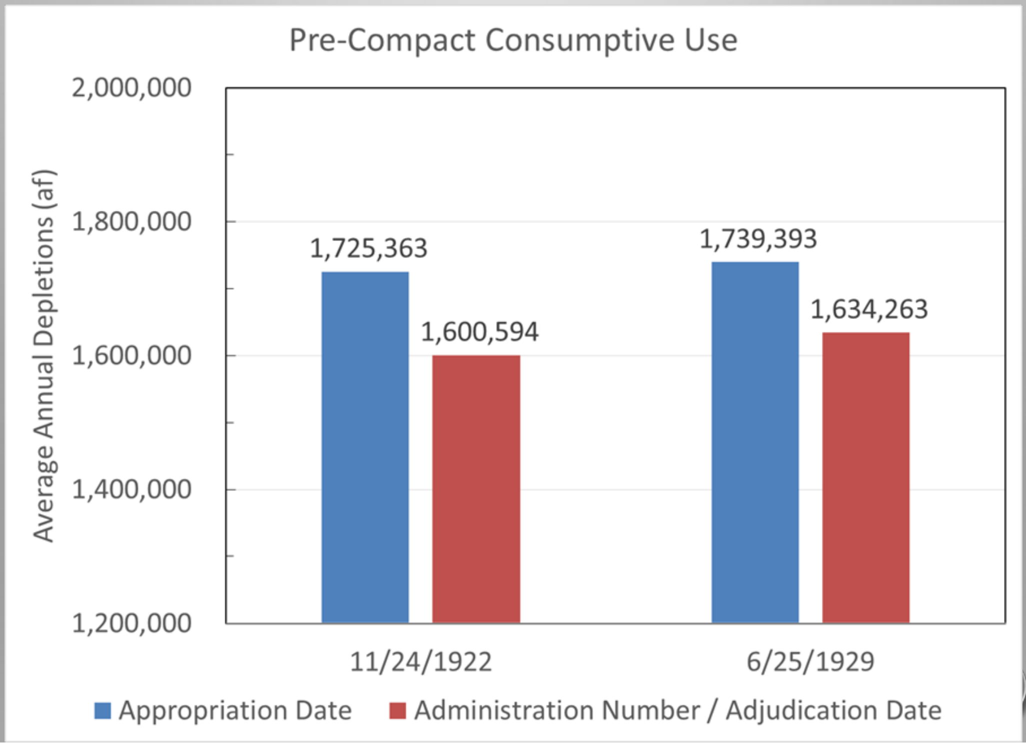
Key Question: How Much Consumptive Use is Pre-Compact?

- Boulder Canyon Project Act (6/25/1929): U.S. Congress approves Colorado River Compact, which was signed by 6 of the 7 basin states on November 24, 1922.
  - Article VIII of the 1922 Compact: "Present perfected rights to the beneficial use of waters of the Colorado River System are unimpaired by this compact…"
- States of the upper basin would most likely attempt to maximize the amount of pre-compact consumptive use
- A point of contention regarding pre-compact rights is likely to be the quantification of "present perfected use" as of 1922.

Appropriation Dates vs. Administration Dates

- Administration of water rights in Colorado is generally based on adjudication dates (represented by admin numbers in StateMod)
- Modeling a Compact Call using appropriation dates yields more pre-compact consumptive use than using administration numbers/dates.



A Closer Look at Pre/Post Compact Depletions

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Who is Impacted by Curtailment of all Post-Compact Rights?

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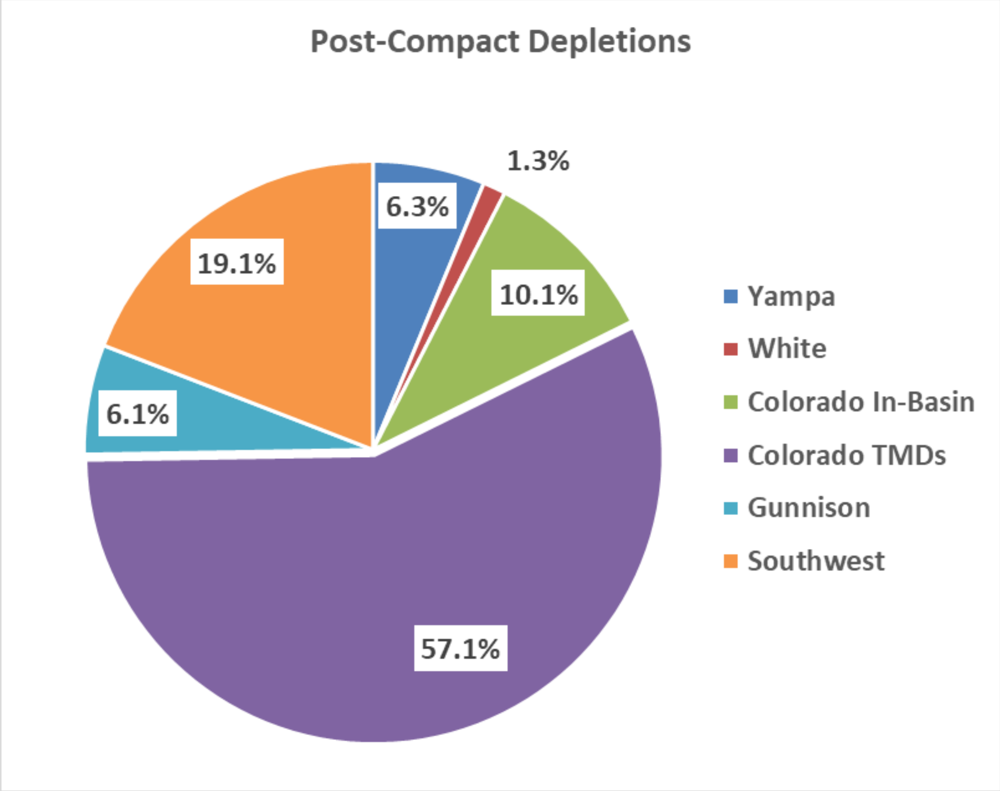
Southwest	178,157	19.1%
Total	931,969	100.0%



What if Curtailment of all Post-Compact Rights is not the only Option?

Q: How deep would administrative call be in order to yield a given volume?

Assume different target volumes for reduced consumptive use:

- 100,000 af
- 300,000 af
- 600,000 af

Recall that a "full" compact call yields about 932,000 af on average

Target Volume (acre-feet/yr)	All Colorado River Rights
100,000	Jul 1957
300,000	Sep 1940
600,000	Aug 1935
932,000	**Nov 1922**

Impact of a Single State-Wide Partial Call on each Sub-Basin

Target Volume (acre-feet/yr)	Yampa	White	Colorado	*In-Basin*	*TMDs*	Gunnison	Southwest
100,000	28%	3%	59%	*22%*	*37%*	6%	8%
(Jul 1957)	27,627	2,753	59,124	*22,309*	*36,815*	5,925	7,528
300,000	16%	2%	59%	*20%*	*39%*	7%	13%
(Sep 1940)	47,987	5,325	177,976	*59,918*	*118,058*	20,862	40,233
600,000	8%	1%	55%	*12%*	*44%*	4%	19%
(Aug 1935)	49,679	8,478	331,556	*69,452*	*262,105*	26,163	113,862
Full	6%	1%	66%	*10%*	*56%*	8%	19%
	58,440	11,888	626,171	*94,403*	*531,834*	57,273	178,163

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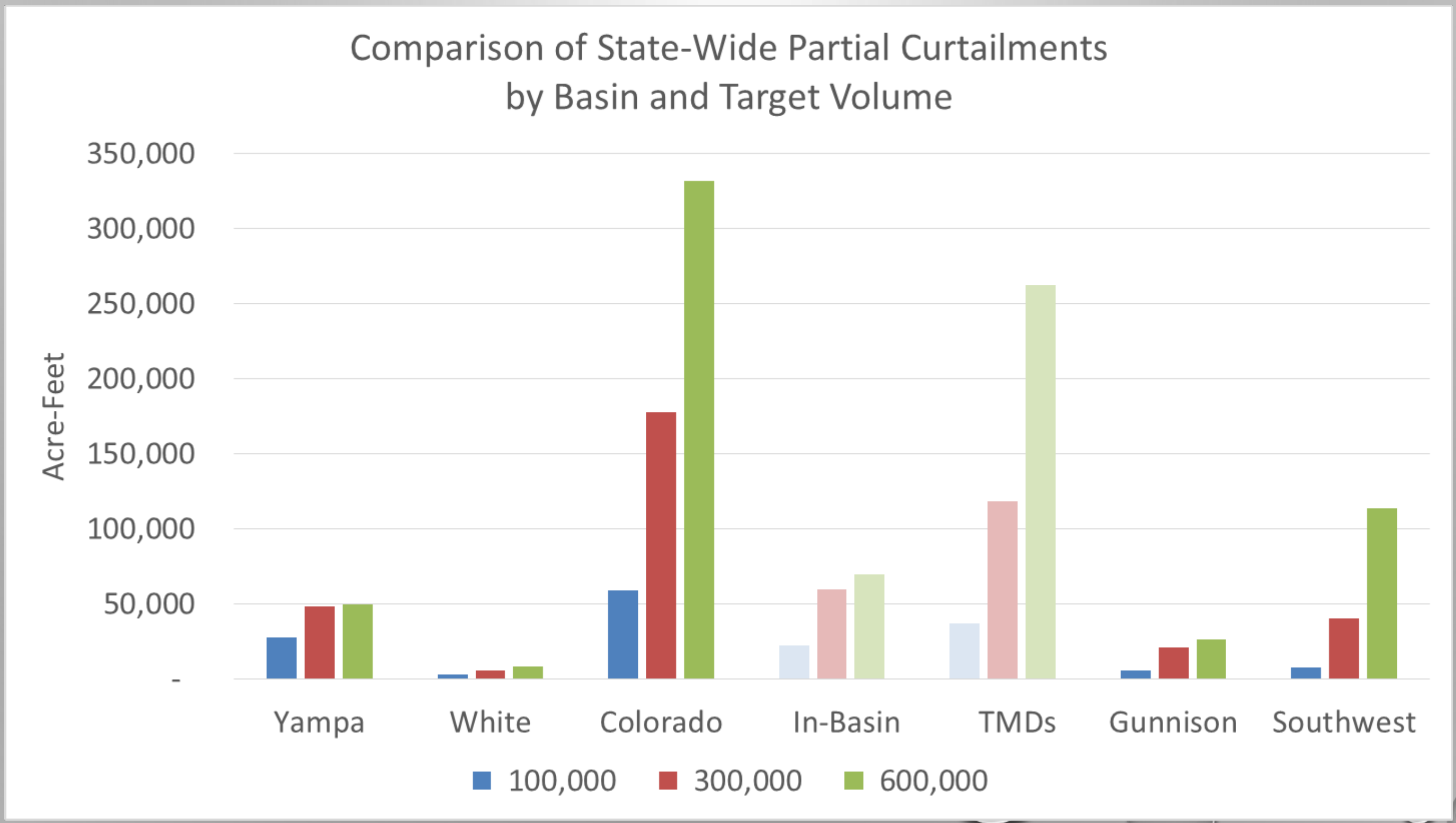
Impact of a Single State-Wide Partial Call on each Sub-Basin



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What if Curtailment According to a Single State-Wide Priority Date is not the only option?

Purpose: Investigate different assumptions regarding the volume and distribution of mandatory curtailment actions *other than* total curtailment.

Examples: Agree to reduce consumptive use via a pro-rata basis. What if*:

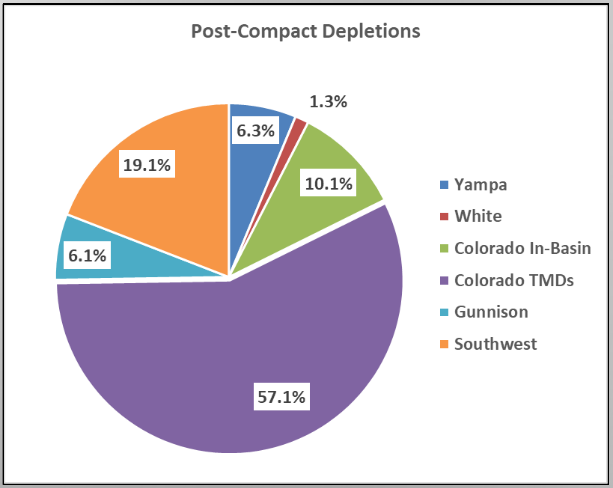
1. We distribute the mandatory reductions based on each sub-basin's percentage of post-compact water use relative to the State as a whole?
2. We distribute the mandatory reductions between in-basin uses and TMDs based on each group's percentage of post-compact water relative to the State as a whole?
3. The in-basin / TMD split is based only on relative uses in the mainstem Colorado (where the vast majority of TMDs occur)?

**These scenarios should NOT be construed as advocating for a particular approach to Compact administration. The intent is to quantify and better understand a variety of possible options.*

Partial Curtailment – by Sub-Basin

Q: How deep would the calls be in each basin to yield these volumes?

Assume that each sub-basin is responsible for reducing consumptive use by a volume of water based on the post-compact depletions *in that sub-basin* relative to the State as a whole



Target Volume (acre-feet/yr)	Yampa	White	Colorado	*In-Basin*	*TMDs*	Gunnison	Southwest
	6.3%	1.3%	67.2%	*10.1%*	*57.1%*	6.1%	19.1%
100,000	6,270	1,276	67,186	*10,129*	*57,064*	6,145	19,116
300,000	18,811	3,827	201,557	*30,387*	*171,191*	18,436	57,348
600,000	37,622	7,653	403,114	*60,774*	*342,382*	36,871	114,697
932,000	58,440	11,888	626,171	*94,403*	*531,834*	57,273	178,163

Partial Curtailment – by Sub-Basin

Example: If Colorado needed to generate 300,000 af annually, the Yampa basin portion of that volume would be ~18,811 af. To reduce average annual consumptive use in the Yampa by that amount would require calling out all rights junior to August 1962

A statewide call to yield 300,000 af requires a September 1940 call

Target Volume (acre-feet/yr)	Yampa	White	Colorado	*In-Basin*	*TMDs*	Gunnison	Southwest
	6.3%	1.3%	67.2%	*10.1%*	*57.1%*	6.1%	19.1%
100,000	6,270	1,276	67,186	*10,129*	*57,064*	6,145	19,116
300,000	18,811	3,827	201,557	*30,387*	*171,191*	18,436	57,348
600,000	37,622	7,653	403,114	*60,774*	*342,382*	36,871	114,697
932,000	58,440	11,888	626,171	*94,403*	*531,834*	57,273	178,163

Sub-Basin Distribution

For a given target volume, administration dates are developed for each sub-basin

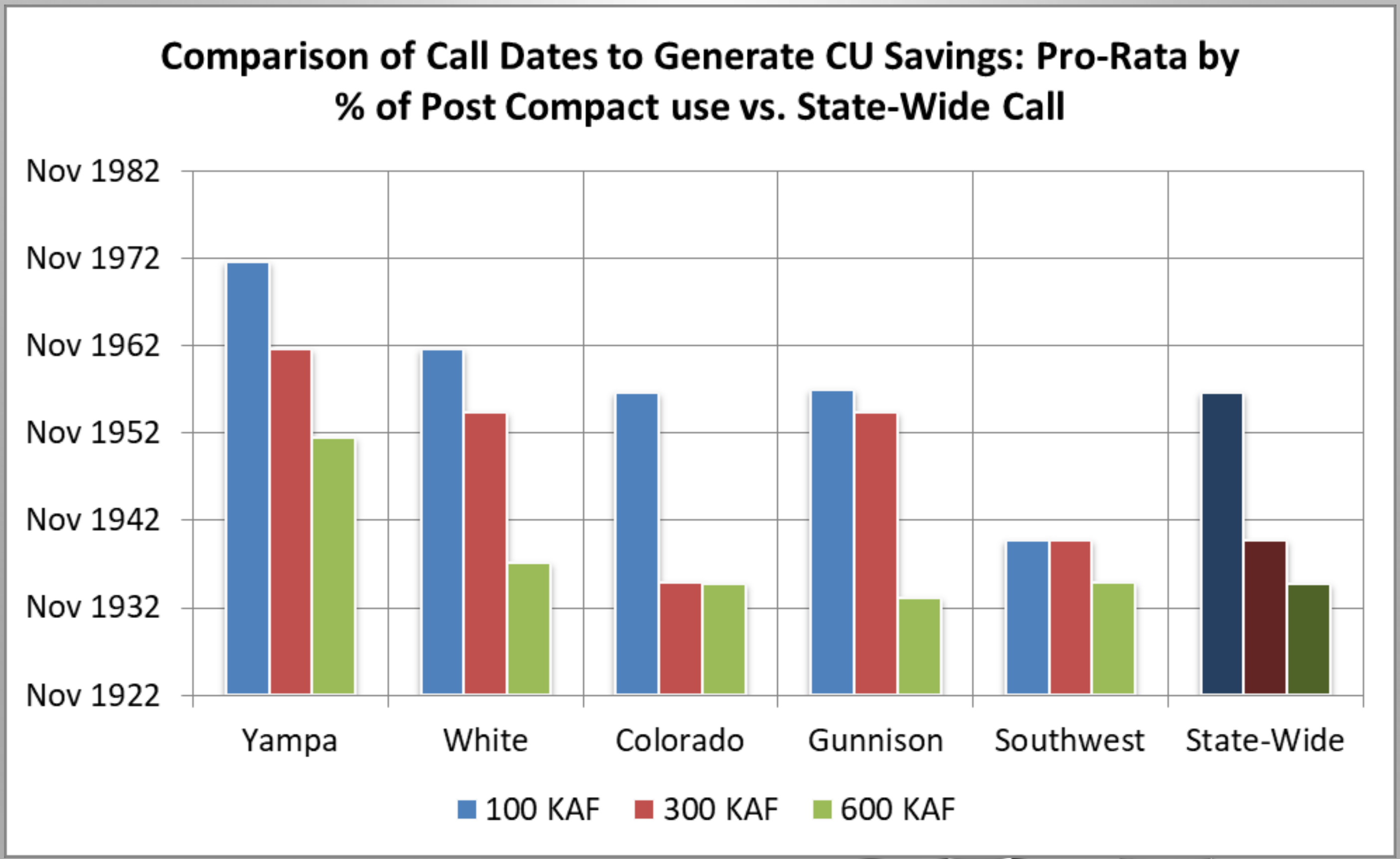
Target Volume (acre-feet/yr)	Yampa	White	Colorado	Gunnison	Southwest
	6.3%	1.3%	67.2%	6.1%	19.1%
100,000	6,270	1,276	67,186	6,145	19,116
	Jul 1972	Jul 1962	Jul 1957	Nov 1957	Sep 1940
300,000	18,811	3,827	201,557	18,436	57,348
	Aug 1962	May 1955	Nov 1935	Apr 1955	Sep 1940
600,000	37,622	7,653	403,114	36,871	114,697
	Jun 1952	Jan 1938	Aug 1935	Dec 1933	Nov 1935

Colorado Mainstem In-Basin/TMD Split

Splitting the mainstem Colorado into in-basin and TMD users relieves some in-basin administration, but TMD call remains essentially the same:

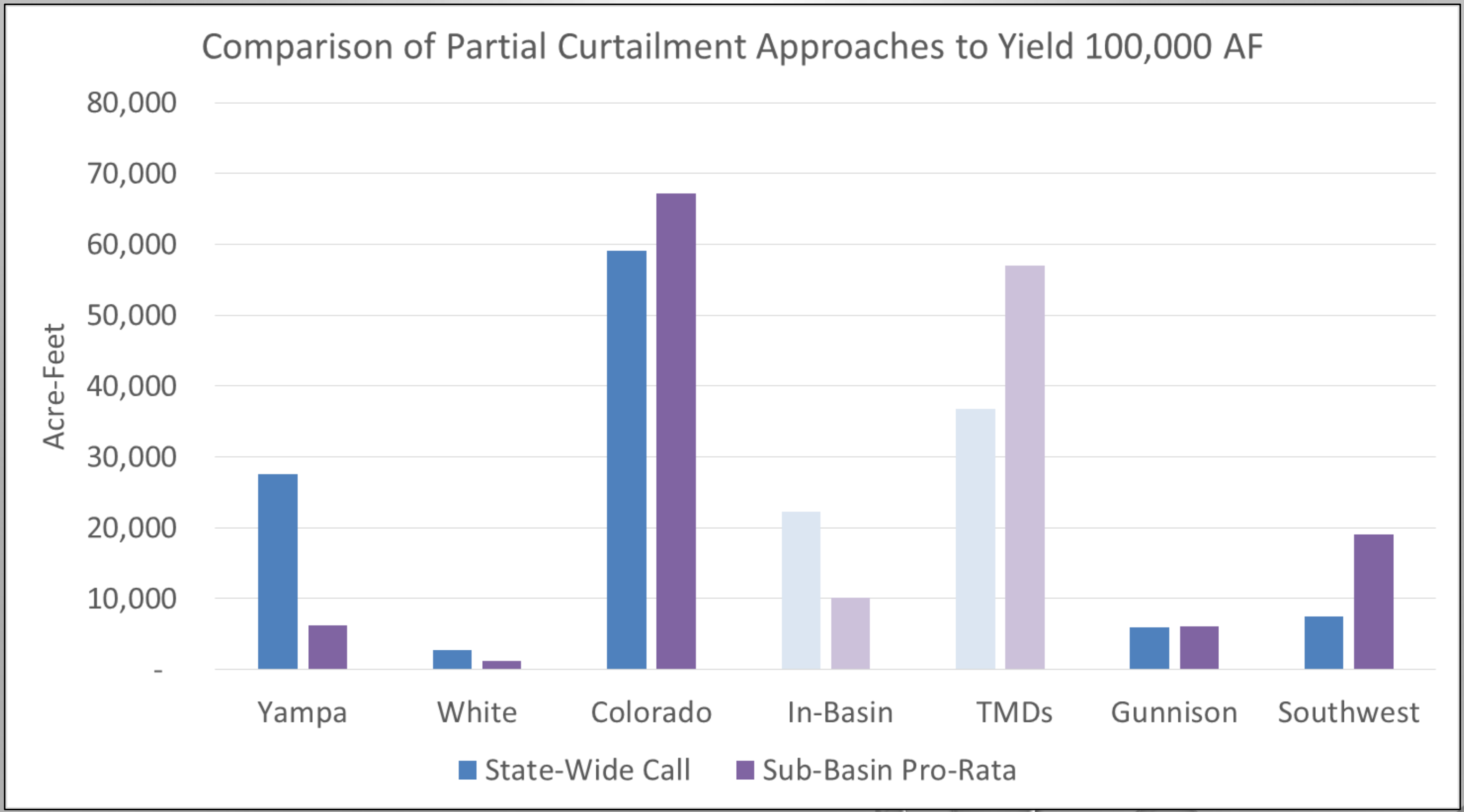
Target Volume (acre-feet/yr)	Colorado	*In-Basin*	*TMDs*
	67.2%	*10.1%*	*57.1%*
100,000	67,186	*10,129*	*57,064*
	Jul 1957	Jan 1981	Jul 1957
300,000	201,557	*30,387*	*171,191*
	Nov 1935	Jul 1957	Aug 1935
600,000	403,114	*60,774*	*342,382*
	Aug 1935	Jul 1941	Aug 1935

How would a Call vary across Sub-Basins (Pro-Rata) Compared to a State-Wide Call?



All Results Presented herein are Preliminary and Subject to Change

Comparison of State-Wide vs Sub-Basin Approaches to Curtailment



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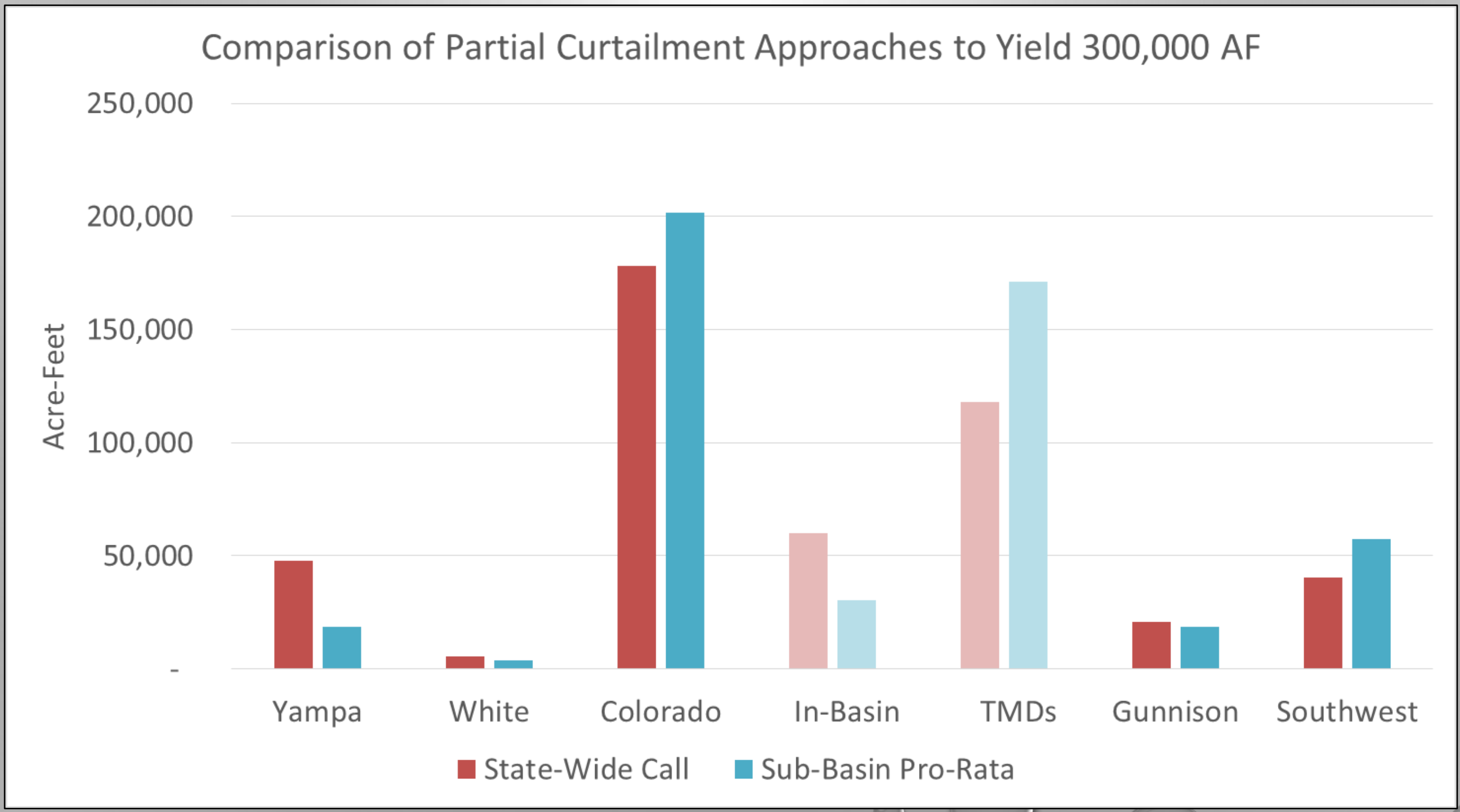
Comparison of State-Wide vs Sub-Basin Approaches to Curtailment



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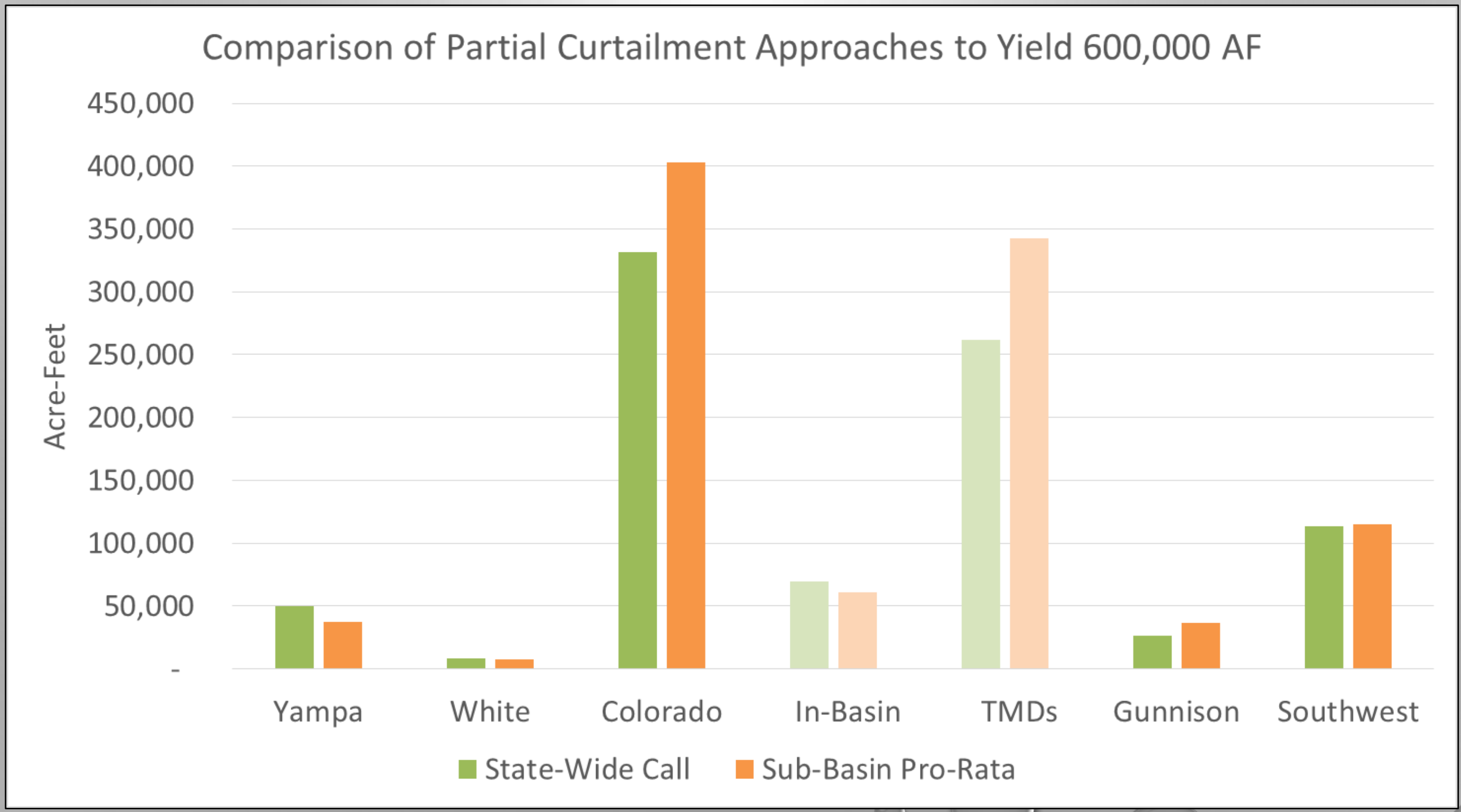
Comparison of State-Wide vs Sub-Basin Approaches to Curtailment



All Results Presented herein are Preliminary and Subject to Change

GENERAL OBSERVATIONS

1. Of Colorado's ~2.5 Maf of average annual consumptive use, approximately ~1.6 Maf is attributable to Pre-Compact rights, and ~900 Kaf is Post-Compact
2. TMDs constitute over half of the Post-Compact depletions (~56%)
3. Because of #2, the Colorado Mainstem users comprise 2/3 of all Post-Compact uses
4. The large TMDs often end up being the swing call, even across different volumetric reductions
5. Allocating deficit volumes pro-rata by sub-basin depletions results in substantially different administration dates for certain sub-basins when compared to a state-wide curtailment of all Colorado River water users.

END

Colorado River Risk Study Phase III Update

June 20, 2019

Modeling Assumptions, Additional Results, and other Background Information.

Disclaimer: The findings presented herein are for discussion purposes only, and do not represent the official position of any entity with respect to factual or legal matters concerning the Colorado River.

All Results Presented herein are Preliminary and Subject to Change

Preamble

The information herein is intended to accompany the handout of slides to be presented by John Carron of Hydros Consulting at the June 20, 2019 Four West Slope Basin Joint Roundtable Meeting in Grand Junction, Colorado. It provides additional background information and results related to the presentation, but is not intended to be a comprehensive report on the work, which will be produced as a Final Report this summer.

Please note that the presentation slides and this supplementary material is intended to provide background information regarding the hydrology, water operations, demands, and associated risk factors that may be considered when formulating future water management policies and strategies. They are not comprehensive in that regard (for example, we make no attempt to quantify the economic costs or benefits of any hypothetical actions), nor should they be taken in any way as a proposal for action or statement of policy by any participating group.

As will become readily apparent in the presentation, the results presented are inextricably tied to the assumptions made about future hydrology, the fate of the 2007 Interim Guidelines, the Drought Contingency Plan, the rate of future growth of demand in the Upper Basin and Colorado, and a number of other model assumption. We are not attempting to forecast the future.

This document is organized into two sections. The first provides a broad overview of the modeling assumptions, including hydrology, demands, river operations, water rights administration, and the generation of output statistics. The second section generally follows the slide presentation sequence, providing additional background information and/or anticipating questions that may arise from those particular slides.

Model Background

1. Modeling Tools

The results presented for Lake Powell and Lee Ferry flows are from model runs simulated using the Colorado River Simulation System (CRSS) see, for example, https://www.usbr.gov/lc/region/g4000/riverops/model-info-APR2018.html). The CRSS Model is available from Reclamation online: http://bor.colorado.edu/Public_web/CRSTMWG/CRSS. This model

has been modified to reflect various components of the Drought Contingency Plan, Minute 323 of the U.S./Mexico Treaty, and to incorporate river flows at the various outflow points from the State of Colorado, which are generated using StateMod (see below, and also the final report from Phase II Task 2 of the Risk Study).

To simulate water use within the State of Colorado, we utilize the StateMod modeling tool available from the Colorado Water Conservation Board (CWCB) (https://www.colorado.gov/pacific/cdss/statemod). The StateMod versions used in this analysis included the "west-slope linked model" provided by the CWCB, and the individual basin models available through the CDSS website.

The linked model has the same basic model structure as used by the State for its Compact Compliance Study. The linked model as provided by the CWCB did NOT include any assumptions regarding methodologies for administering a compact call, nor did it include any alternate hydrology or demand data outside of what can be obtained from the CDSS website. We also employed the individual basin models for each west slope sub-basin. These are the "Yampa/White", "Colorado", "Gunnison", and "San Juan/Dolores" basins. The Yampa/White basin model is actually two separate model networks, and so results are presented separately for those two basins.

2. Model Assumptions

Hydrology:

The hydrologic basis for the modeling results herein is the so-called "Stress Test Hydrology" which covers the calendar years 1988-2015. The Stress Test hydrology was used extensively by Reclamation and the Upper Colorado River Commission when evaluating possible actions for the Drought Contingency Plan, and was also used in Phases I and II of this study.

None of the StateMod models used for this work extend through 2015. As a result, we appended data for the "missing" years by examining historical flows at gage locations for both the missing years and other available years in the model database. The missing years were then "filled" by using years that most closely replicated the gage volumes. This also allowed us to synchronize the StateMod model with the CRSS model, which already contained the full Stress Test period hydrology.

Water Rights Administration:

We use two different approaches to simulate water rights administration in StateMod. The default behavior in StateMod is to use the administration numbers assigned to each water right when simulating priority administration of each basin. A water right's administration number is generally based on its adjudication date, prior adjudication dates, and its appropriation date. Use of the administration numbers is StateMod is consistent with the generally accepted understanding of how rights are administered "on the ground".

The second approach is to use appropriation dates. When considering both the Colorado River Compact and potential administration across sub-basins within Colorado, it is worth considering differences in the timing of sub-basin adjudications, and also the interplay in timing between adjudication dates and the enactment of the Compact. It is also important to note that an appropriation date in and of itself does

not guarantee a pre-compact right, as the use of that water may not have been perfected by the date of the Compact.

Unless otherwise noted, we use the administration number paradigm for the StateMod analyses in this study.

Demands:

Two different data sets were used to represent “current” and “future” demands. For StateMod, the baseline data set is the best estimate of current demands within Colorado. The purpose of the “future” demand data set was to illustrate how an increment of additional consumptive use could impact the level of risk in the upper basin. Through coordination with the west-slope BRT technical representatives, we developed a “reasonable increment” of growth for each basin. In basins with Programmatic Biological Opinions (PBOs), we based the increment of growth on assumed full use of the PBO “allowances”. For basins without PBOs, we developed additional demands that were subjectively similar in scope to those developed under the PBOs, and to the extent possible based on existing decrees, projects, or published studies and reports. These future demands were added to the StateMod model(s) and a new set of depletions and basin outflows were developed*.

The table below shows the new demands by basin in the right-hand column. The average yield of the new demands is shown in the left column of data, and the total increase in consumptive use by basin is shown in the center column. Note that introduction of new demands on the system does not necessarily translate into additional depletions of the same volume. In the Colorado and Southwest basins in particular, new demands may be limited due to hydrologic shortages, particularly in dry years. The average annual increase in consumptive use of Colorado River Basin water in Colorado resulting from the addition of ~384 Kaf of new demands was slightly less than 290 Kaf, or about 11.5% of the current average annual depletion.

The values developed for the hypothetical future use in Colorado needed to be replicated for the other states of the Upper Basin in order to run future scenarios in CRSS. Using Colorado’s current (2019) share of demands under the 2016 UCRC demand schedule we matched the 11.5% increase for Colorado with an upper-basin-wide increase of 11.5%. That increase in use is approximately equivalent to 2037 demands in CRSS (using the 2007 UCRC demand schedule). Thus, when running CRSS for future use projections, Wyoming, Utah, and New Mexico demands were based on the 2037 demand level, which is an increase over current demands of about 300 Kaf for those three states.

StateMod Linked Model	Future Use Depletions (AF/yr)		
	Average Yield of New Depletions	Average Increase in Basin Depletions	Input Demand
Yampa	29,506	29,485	30,104
White	61,839	61,787	65,000
Upper Colorado & Front Range	86,077	82,425	120,450
Gunnison	31,053	31,100	37,900
Southwest	81,104	82,355	130,499
StateWide	**289,578**	**287,153**	**383,953**

**Note: The "future" demands shown are NOT intended to advocate for any specific projects, to limit or push any specific level of development, or to suggest appropriate allocations of growth across sub-basins. The purpose of simulating these demands is primarily to develop an understanding of how increased consumptive use in the upper basin as a whole may impact the likelihood of reaching critical elevations at Lake Powell or critical volumes at Lee Ferry.*

<u>Trans-Mountain Diversions (TMDs):</u>

As much as 500 Kaf of water is diverted from the Colorado River Basin into other basins within the State of Colorado. These diversions can be found in most Colorado sub-basins. Well over 95% of TMD water is diverted from the mainstem of the Colorado River itself. An even higher percentage of the TMDs used for M&I water originate from the Colorado mainstem. For this study, we only examine Colorado mainstem TMDs and the impact of a potential compact call on those water users.

<u>CRSS River Operations</u>:

The CRSS model simulates operations of many of the large Federal storage projects within the basin. Within Colorado this includes the Aspinal Unit and Taylor Park Reservoir. The other major CRSP reservoirs are also simulated (Powell, Navajo, Flaming Gorge), as well as the large main stem reservoirs in the Lower Basin (Mead, Mohave, Havasu). Operating policies for the Upper Basin CRSP facilities are based primarily on the Records of Decision for each (including the 2007 Interim Guidelines that dictate Lake Powell operations), and are part of the "standard" ruleset for the CRSS model.

Drought Contingency Plans (DCPs) and Minute 323 of the US/Mexico Treaty: CRSS was modified to incorporate the major components of the recently approved DCPs and Treaty Minute 323. For the Upper Basin, we only include the proposed Drought Operations of the CRSP facilities in the model. The Drought Operations ruleset was developed jointly by the UCRC Engineering Committee and Reclamation during DCP negotiations. The final version used by Reclamation in its DCP modeling is included in our simulations. No attempt was made to incorporate demand management or cloud seeding/flow augmentation in our modeling.

For the Lower Basin DCP, the model reduces deliveries to the states as laid out in the Lower Basin DCP agreement, and includes an assumed annual contribution by Reclamation of 100 Kaf. Minute 323 is also represented in the model, and reductions in deliveries to Mexico through their pro-rata "matching" of both the Interim Guidelines shortages and the DCP reductions are included.

<u>Model Execution and the Index Sequential Method</u>:

The CRSS model uses the "Index Sequential Method" (ISM) to perform multiple simulations using a single hydrologic data set. In this study, the Stress Test hydrology spans the period 1988-2015. That 28 year period of data is used to develop 28 different hydrologic traces. Each of these traces is then modeled in CRSS. Each simulation (<u>trace</u>) starts with a different year. The first trace is 1988-2015. The second trace begins with year 1989, runs through 2015, then appends 1988 as the last year of the trace. The third trace begins in 1990, runs through 2015, and then appends 1988 and 1989 onto the end. In this fashion, each year of the stress test period is used once as the start year, and the traces "loop through" the historical period.

Slide Presentation Addenda

Slide #3:

The entire text of Principle 4 reads:

"***Principle 4: A collaborative program that protects against involuntary curtailment is needed for existing uses and some reasonable increment of future development in the Colorado River System, but it will not cover a new TMD.***

A collaborative program that protects existing uses and an increment of future development is a necessary element of Colorado's water planning, regardless of whether a new TMD is developed. The Framework includes this principle to make clear that a collaborative program would not protect a new TMD.

The collaborative program should provide a programmatic approach to managing Upper Division consumptive uses, thus avoiding a compact deficit and ensuring that system reservoir-storage remains above critical levels, such as the minimum storage level necessary to reliably produce hydroelectric power at Glen Canyon Dam (minimum power pool). A goal of the collaborative program is that protection of Colorado River system water users, projects, and flows would be voluntary and compensated, like a water bank. Such protection would NOT cover uses associated with a new TMD.

A second goal of the collaborative program is protection of the yield of the water supply systems in place in the Colorado River Basin from involuntary curtailment. To achieve this goal, the program would need to expand to accommodate future western slope growth and growth of existing water supply systems, the pace of which is not now known. Protecting additional consumptive uses will increase the program's scope and challenges. Some basins, such as the less-developed Southwest and Yampa/White/Green Basins, anticipate the need for future development and will seek terms to accommodate it in the collaborative program. Regardless of "when" a use develops, the program would strive to protect uses at the time of shortage, with the exception of a new TMD. By adapting to accommodate increased uses at any given time, the program should not lead to a rush to develop water rights. Section 9.1 of Colorado's Water Plan provides additional discussion of the collaborative program.

The collaborative program will develop in concert with intra- and interstate water policies. The IBCC and roundtables can provide an important forum for sharing the work of ongoing interstate negotiations, scoping technical analyses, and identifying issues of concern at the stakeholder level, as well as providing input to the CWCB as it manages and conducts the technical, legal, economic, and other studies necessary for implementation.

Slide #4:

Why elevation 3,525'? Section II.A.2 of the AGREEMENT FOR DROUGHT RESPONSE OPERATIONS AT THE INITIAL UNITS OF THE COLORADO RIVER STORAGE PROJECT ACT on the rationale for using 3525' as the Lake Powell target elevation:

Target Elevation: For purposes of this Drought Response Operations Agreement only, Lake Powell surface elevation 3,525 feet mean sea level ("msl") will be considered the "Target Elevation" for minimizing the

risk of Lake Powell declining below minimum power pool (approximately elevation 3,490 feet msl) and to assist in maintaining Upper Division compliance with the Colorado River Compact. The Parties agree that this elevation appropriately balances the need to protect infrastructure, compact obligations, and operations at Glen Canyon Dam, as storage approaches minimum power pool with the Upper Division States' rights to put Colorado River System water to beneficial use.

Elevation 3,525 is also the threshold for the Lower Elevation Balancing Tier of operations under the 2007 Interim Guidelines:

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage** (maf)
3,700		**24.32**
	Equalization Tier equalize, avoid spills or release 8.23 maf	
3,636 – 3,666 (see table below)		**15.54 – 19.29** (2008 – 2026)
	Upper Elevation Balancing Tier release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	
3,575		**9.52**
	Mid-Elevation Release Tier release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	
3,525		**5.93**
	Lower Elevation Balancing Tier balance contents with a min/max release of 7.0 and 9.5 maf	
3,370		**0**

(Record of Decision – Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead, p.50.)

Note that releases under the Lower Elevation Balancing Tier could be as large as 9.5 Maf, while the maximum release in the Mid-Elevation Release Tier is 8.23 Maf.

<u>Slide #5:</u>

The May 2019 24-Month Study from Reclamation (https://www.usbr.gov/lc/region/g4000/24mo.pdf) forecasts that Lake Powell will end 2019 with 12,368,000 acre-feet of storage. That number is developed from the Colorado Basin River Forecast Center's most probable inflow data for the remainder of 2019 and projected releases, evaporation, and changes in bank storage through December 31.

Slide #6:

The “Stress Test Period” covers the calendar years 1988-2015. The average naturalized flow during that period is 13.18 Maf, with a maximum annual natural flow of 20.3 Maf in 2011, and a minimum of just over 6.0 Maf in 2002.

The average annual flow over the period of record (1906 – 2018 provisional) is 14.75 Maf.

The average annual flow over the period 2000 – 2004 is 9.55 Maf.

The average annual flow over the period 2000 – 2018 (provisional) is 12.36 Maf.

(Statistics above derived from data provided by Jim Prairie, Upper Colorado Region, Reclamation; May 3, 2019)

All of the modeling results presented herein are based on simulations using the Stress Test period hydrology. For this work we did not consider paleo-hydrology or climate change forecasts.

Slide #7:

For an overview of the modeling tools and assumptions used in this analysis, refer to the ***Model Background*** section above.

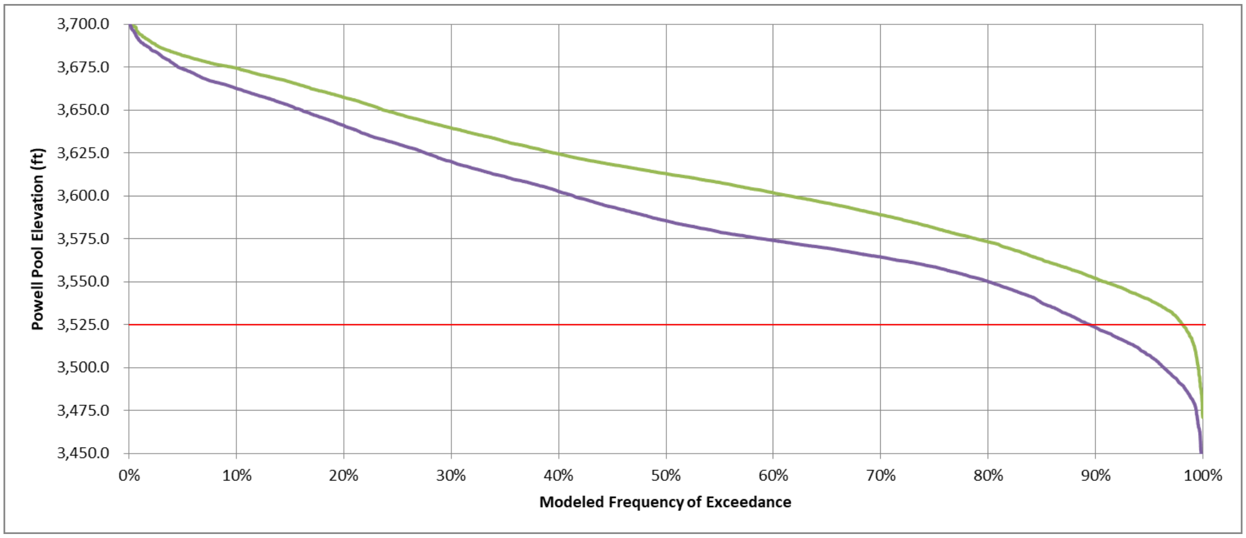
Background on the statistics presented in bullets 1-3: Recall that using the ISM method, the model generates a total of 28 traces, resulting in 28 simulations. For this study, we perform statistical analysis on the first 25 years of each simulation. Thus for the “current conditions” run there are a total of 28 traces x 25 years per trace = 700 years of data. There are two main statistical approaches we use to evaluate the outputs.

One is to quantify the likelihood that a specific event happens in any year across all the traces. Using Lake Powell Elevation as an example, we might count the number of years that Lake Powell drops below 3525 on January 1. If we find 11 such occurrences, then the likelihood of Lake Powell hitting that elevation in any given year would be 11/700 = 1.43%.

The second approach is to quantify the number of traces in which a particular event occurs. Keeping in mind that each trace is a hypothetical projection into the future, we would want to understand how many of those possible futures contain a bad outcome. It may not necessarily matter if it happens next year or in 20 years, we just want to know IF it happens. Now let’s assume that each of those 11 events mentioned above happened in different traces (our “futures”). Of all our assumed futures, 11/28 or ~39% are likely to encounter this condition at some point in the next 25 years. Now the risk looks very different, even though it is based on the same data.

This second approach, looking across the possible futures, is the method we use to generate the statistics for Slide #7.

The following exceedance curve uses the first approach, and the same model outputs for current and future demand runs as used for Slide 7. The difference between these two statistical methods explains why the exceedance curve - showing modeled likelihood across <u>all years</u> - can be perceived to represent a very low risk.



<u>Slide #8:</u>

Hopefully the previous presentation on the DCP provided sufficient background on this slide.

<u>Slide #9:</u>

The definition of a compact deficit itself is far from settled, and we are not going to delve into that question here. Nor is it a foregone conclusion that a deficit, if and when it does occur, would result in an involuntary curtailment.

<u>Slide #10:</u>

The data in this slide is developed from the individual CDSS (StateMod) basin models. The models use the current conditions (baseline) demand set from the CDSS website. These depletion values include evaporation and other losses incidental to water use. The variability in consumptive use is a result of hydrologic variability and the resulting simulation of junior users being called out in the model. For this and most subsequent slides, the main stem Colorado depletion values will be presented as a whole, as well as split into in-basin and trans-mountain diversion (TMD) uses.

<u>Slides #11 - 12:</u>

The questions surrounding the definition of pre-compact vs post-compact water rights (and perfected use) are numerous and beyond the scope of this work. Slide 12 shows the differences between the 1922 and 1929 compact dates, when determining pre-compact water use in Colorado. The default behavior for StateMod is to use Administration Numbers – which are derived largely from adjudication dates – when simulating water allocation. StateMod can also use appropriation dates to simulate the administration of water. Using appropriation dates instead of administration numbers when modeling a compact call yields between 105 Kaf and 125 Kaf additional pre-compact consumptive use in Colorado, depending on the assumption of compact date of enforcement. The results in this presentation related to a full compact call are based on model simulations that use administration numbers, and the Nov 24, 1922 compact date.

Slide #13:

To simulate the effects of a compact call on all post-compact rights, and to determine the total amount of (modeled) pre-compact consumptive use, we apply an infinitely large demand at the bottom (state line) of each model, with a priority date of 11/24/1922. Because there could be significant inter-annual variability in yield based on hydrology, we simulate the call for the entire simulation period, and then compute the average consumptive use across all years. This average pre-compact consumptive use totals ~1.6 Maf, and is shown in the middle column. The first column is from slide 10, and the third column is simply the percent of each basin' consumptive use that is attributable to pre-compact rights.

Slide #14:

The average annual volume of post-compact consumptive use is computed by subtracting the pre-compact average from the total average for all users. This difference represents approximately 932 Kaf of consumptive use by post-compact rights. The table percentages show the distribution by basin of those post-compact rights relative to the total, and the pie-chart is a visual representation of those percentages.

Slides #15-#26:

The results in this group of slides are based on a number of different "what-if" scenarios. The purpose of these scenarios is NOT to advocate for a particular approach to involuntary curtailment, nor to exclude any other possible approaches.

Slide #15:

What if…

Perhaps a total curtailment of all post-compact rights is not necessary to overcome a compact deficit, or perhaps an agreement is reached whereby Colorado water users must curtail a certain amount of consumptive use over some period of time. One obvious question would be, "*how deep would a call across all basins using a single administration number need to be in order to yield a certain volume of reduced consumptive use*"? To answer this question, we turned to the linked StateMod model that combines all the west-slope basin models into a single model that can be used to simulate the impact of a single call on all Colorado River water users.

To estimate the administration dates in the table, we place a large "demand" at the outflow point of the linked model, and iterate the model at different administration dates until we achieve the desired average yield. So for example, on average, to achieve a statewide reduction of 300,000 af. would require curtailment of all rights junior to September 1940.

To reiterate: all these simulations use administration numbers (based largely on adjudication dates), not appropriation dates, when simulating calls. The difference between depth of call when simulating these volumes using those two different administrative schemes is very small.

Slide #16:

This slide simply takes the total volumes and call dates computed in the previous slide, and breaks out how much reduction in consumptive use would result in each of the sub-basins. For example, a state-

wide September 1940 call would result in curtailment of an average of 40,233 af. in the San Juan/Dolores (Southwest) basin, or about 13% of the 300,000 af. total.

Slide #17:

This graphic is simply a bar chart reproduction of the data from the previous slide. The lighter colored "In-Basin" and "TMD" bars are the breakout of the Colorado mainstem total into those two constituent user types.

Slide #18:

In Slides #15-#17, we explored what a partial call across all basins using a single administration number might look like. Another approach might be to allocate the volume of required consumptive use reduction pro-rata, across the sub-basins, based on each sub-basin's percentage of *post-compact* use. We can also explore the split in post-compact use between in-basin and TMD use in the Colorado mainstem.

Slide #19:

To develop a pro-rata distribution of each sub-basin's hypothetical obligation to meeting the state-wide total reduction, we apply the percentage of post-compact use by sub-basin that was shown in slide #14, and compute each sub-basin's portion. The volumetric requirements under this hypothetical approach are shown in the table.

Slide #20:

Under the scenario described in the previous slide, each sub-basin is responsible for its own pro-rata reduction in post-compact depletions. There are a number of different ways those sub-basins could agree on to reduce that volume of use. One such approach would be to implement a call within that sub-basin to a seniority that would yield the required volume.

For example, if the State is required to conserve 300,000 af, the Yampa basin's portion of that volume under this approach would be 18,811 af. Using the Yampa StateMod model, we can compute a call date of August 1962 that would yield, on average, that volume of reduced consumptive use.

Slide #21:

We again perform a set of runs in StateMod using each sub-basin model to determine the call seniority by sub-basin that would be required to generate the target volumes. Those dates and associated volumes are shown in the table.

Note that a comparison can be made for each basin, by date and volume, with the state-wide call date shown in slide #15.

Slide #22:

Another hypothetical we can explore is allocating responsibility on the Colorado mainstem between in-basin post-compact uses and TMD post-compact uses (The vast majority of TMD consumptive use is post-compact). We only perform this analysis on the Colorado mainstem, as TMDs from other sub-basins are a very small percentage of total water use in those basins.

The Colorado mainstem as a whole consumes 67.2% of post-compact water in the State. That 67.2 percent is split into 57.1% (of the state-wide total) for the TMDs, and 10.1 % of the state-wide total for in-basin Colorado mainstem users.

As a percent of the Colorado mainstem alone, TMDs constitute 85% of post-compact use, with in-basin use comprising the remaining 15%.

Note that the call seniority is largely unchanged for the TMDs, but the in-basin call seniority is somewhat relaxed by this approach.

Slide #23:

From the above analyses, we can compare a state-wide call with a pro-rata distribution based on post-compact use, and see which sub-basins would experience deeper or shallower calls and associated volumes of use reduction.

Again, these call dates are the seniority required *on average* to yield the target volumes.

Slides #24-#26:

This set of slides aggregates the previous data into a comparison of these partial curtailment approaches and presents them by volume, and across each sub-basin. Note that the lighter shaded bars represent the breakout of Colorado mainstem uses into in-basin and TMD components.

Slide #27:

This is a short and necessarily incomplete summary of observations. These observations are not intended to be comprehensive, but to be a launching point for additional conversation.